Research Note 85-3

ANALYSIS OF TOW GUNNERY TRAINING

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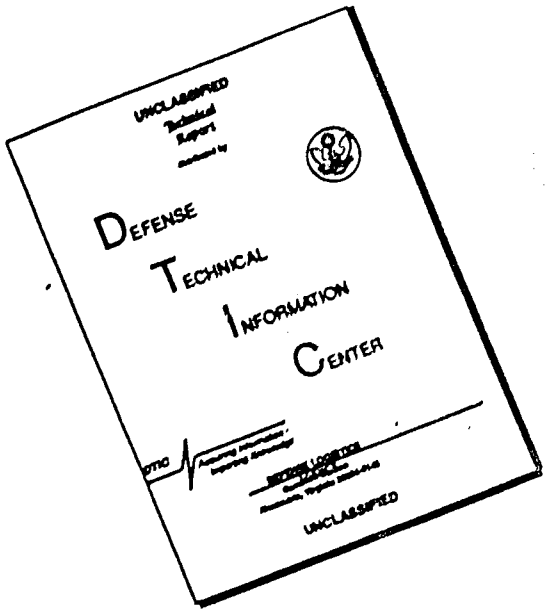

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Recent U.S. Army Training and Doctrine Command (TRADOC) studies indicate that for the majority of Army systems, training does not optimize total system effectiveness. These same studies show that existing practices tend to underutilize training resources. Because of these findings, TRADOC initiated the Training Effectiveness Analysis (TEA) effort and directed the U.S. Army Infantry School (USAIS) to conduct TEAs for the M16A1 Rifle, the TOW, and the Dragon Weapon systems. In support of the USAIS, the U.S. Army Research Institute (ARI) has initiated TEA-related research for these weapons. One of the purposes of the

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ARI reaearch is to identify both short and long range improvements in TOW gunnery training. A necessary prerequisite for accomplishing this task is the documentation and analysis of the current gunnery training for the TOW system. This report presents a description of current TOW gunnery training and discusses the implications of an analysis of this training for identifying improvements and cost-effective alternatives for TOW gunnery training.

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1473 B

FOREWORD

This report is provided by the Mellonics Systems Development Division of Litton Systems, Inc., to the Army Research Institute for the Behavioral and Social Sciences (ARI) under Contract Number DAHC19-77-C-0011 This report is part of the final report of the total research support effort and will be incorporated in that report by reference.

Under the contract, a part of Mellonics' effort concerns support to the Training Effectiveness Analysis (TEA) research presently being conducted by the ARI for the United States Army Infantry School (USAIS). One portion of the TEA research involves the identification of improvements and the development of cost-effective alternatives for training M16A1 marksmanship and TOW and Dragon gunnery. A necessary prerequisite for accomplishing these tasks is the documentation and analysis of the current training for these weapons. This report presents the documentation and analysis for the TOW Weapon System. The documentation and analysis for the M16A1 Rifle and the Dragon Weapon System are published separately.

ABSTRACT

Recent U.S. Army Training and Doctrine Command (TRADOC) studies indicate that for the majority of Army systems, training does not optimize total system effectiveness. These same studies show that existing practices tend to underutilize training resources. Because of these findings, TRADOC initiated the Training Effectiveness Analysis (TEA) effort and directed the U.S. Army Infantry School (USAIS) to conduct TEAs for the M16A1 Rifle, the TOW, and the Dragon Weapon systems. In support of the USAIS, the U.S. Army Research Institute (ARI) has initiated TEA-related research for these weapons. One of the purposes of the ARI research is to identify both short and long range improvements in TOW gunnery training. A necessary prerequisite for accomplishing this task is the documentation and analysis of the current gunnery training for the TOW system. This report presents a description of current TOW gunnery training and discusses the implications of an analysis of this training for identifying improvements and cost-effective alternatives for TOW gunnery training.

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INTRODUCTION

Recent U.S. Army Training and Doctrine Command (TRADOC) studies indicate that for the majority of Army systems (particularly weapon systems), training does not optimize total system effectiveness.[1] These same studies show that existing practices tend to underutilize training resources. Because of these findings, TRADOC initiated the Training Effectiveness Analysis (TEA) effort. The objective of TEA is to produce improvements in training through analysis and redesign of the procedures and training resources used to implement current training programs. The analysis and redesign are to lead to more cost-effective alternatives for training.

Accordingly, TRADOC has directed the U.S. Army Infantry School (USAIS) to conduct TEAs for three Infantry weapon systems: the M16A1 rifle, the TOW (Tube-Launched, Optically-Tracked, Wire-Command Link) heavy antitank weapon, and the Dragon medium antitank weapon. In support of the USAIS, the U.S. Army Research Institute (ARI) has initiated TEA-related research for each of these weapon systems. One of the purposes of the ARI research is to identify both short and long range improvements in current system training.

The Mellonics Systems Development Division of Litton Systems, Inc., under contract to the ARI, is supporting the TEA research presently being conducted at the Fort Benning ARI Field Unit. One portion of this research involves the identification of improvements and the development of cost-effective alternatives for TOW gunnery training. A necessary prerequisite for accomplishing these tasks is the documentation and analysis of the current gunnery training for this system. As part of its support to the ARI, Mellonics was requested to perform the required documentation and analysis of training. This report presents the research findings and discusses their implications for improving TOW training.

OBJECTIVES

The objectives of this research are:

- o To describe the current training objectives, practices, and quality control procedures for TOW gunnery training;
- o To discuss the implications of these analyses in identifying improvements and cost-effective alternatives for TOW gunnery training.

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[1] Department of the Army. Analyzing training effectiveness (TRADOC PAM 71-8). Washington, D.C.: Author, December 1975.

METHOD

The documentation and analysis of a training program requires (at a minimum) information on the following:

- o Program training objectives;
- o Program training practices;
- o Program organization;
- o Program instruction and practice requirements;
- o Program quality control procedures.

A survey of the military literature revealed that two programs of instruction (POIs) are employed to teach TOW gunnery training at the individual level: the POI outlined in TC 23-20[2] and the POI for the USAIS Post-AIT (Advanced Individual Training) TOW gunnery course. Of these programs, only the USAIS program was found to provide the above information. For this reason, the analysis of current TOW gunnery training has been limited to this program.

The data base for this analysis consisted of four sources of information. These were:

- o the POI;
- o the lesson plans for the POI;
- o interviews with personnel involved in the conduct of the USAIS program;
- o field observations of training.

The documentation and analysis of the USAIS program were accomplished in the following manner. First, the POI and the lesson plans were examined to derive program training objectives and organization. Next, specific instruction and practice requirements were identified from a study of the program lesson plans. Later, quality control procedures were identified from cadre interviews and field observations of training. Finally, the results of the analysis were assessed and suggestions for improvements in current TOW gunnery training were derived.

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[2] Department of the Army. Unit antiarmor training program (Training Circular 23-20). Washington, D.C.: Author, August 1975

DOCUMENTATION OF TOW TRAINING

TOW GUNNERY TRAINING - AN OVERVIEW

The purpose of a gunnery training program is to train selected personnel in the use of a designated weapon system so that the engagement of targets and subsequent target hits have a high probability. In the ideal case, a gunnery program is arranged to train in system nomenclature, operation, and maintenance and to train in the fundamentals of gunnery, e.g., the assumption and maintenance of appropriate firing positions, target-weapon system alignment, and system firing procedures. In the ideal program, concurrent with or following instruction, opportunities to practice the application of the fundamentals in live-fire situations are provided. During this practice trainees engage and fire on specified arrays of targets using live ammunition. The assumption underlying the practice is that such practice leads to successive improvements in firing proficiency and to ultimate proficiency levels which insure high probabilities of hit.

However, the cost of live-firings for the TOW system is quite high. In Fiscal Year 1976, a single XBTM71A TOW practice missile cost $ 3,242 to fire.[3] A training program based on 100 live-firings per man of this missile would cost at least $324,000 per man in Fiscal Year 1976 dollars. A less expensive alternative is to base TOW gunnery practice on simulated missile firings. In the developmental phase of the TOW system, this problem was recognized and a simulator developed. This was the M70 training set.

The M70 training set[4] consists of an instructor console, a missile simulation round, and a target set. To use the M70 trainer, the instructor console is connected to the TOW system, the missile simulation round is loaded in place of a live missile, and the target set is installed on a vehicle. During a simulated firing trial, the training system is manned and operated in exactly the same manner

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3 U.S. Army Combined Arms Training Board. Special analysis of TOW training (U). Fort Benning, GA.: Author, March 1975. Confidential.

4 The description of the M70 training set and its use during practice firing is based on information found in the following source: Department of the Army. TOW heavy antitank weapon system (Training Circular 23-23). Washington, D.C.: Author, July 1970.

as the tactical system during a live-fire trial.[5] This procedure is described below:

> A vehicle with the target set assumes a specified position down-range from the M70 training system. The target set is turned on and a continuous infrared signal is emitted that simulates the signal emmitted by a TOW missile during flight.
>
> Depending on the target protocol for the trial, the target vehicle remains stationary or moves laterally left-to-right or right-to-left at a designated speed. When the trainee acquires the target's infrared source, i.e., the cross hairs of the optical sight are placed on the infrared source, he presses the TOW trigger. At this time the infrared sensor in the optical sight detects the infrared emmissions of the target. Next, error signals proportional to azimuth and elevation displacements of the optical sight with respect to the target are transmitted to the guidance set and instructor console. The console converts these signals into a score which is an approximation of the percent of time that the optical sight is kept directly aligned with the target. This score is displayed throughout the simulated firing trial. At the end of the trial, a final score is displayed which is an approximation of the percent of time the sight was kept on the target for the entire trial.

As it now exists, the M70 training system also provides for simulating missile flight time. This is accomplished by selection of either a "low- or a high-rate qualify" setting on the RANGE switch control of the instructor console. If a "low-rate qualify" setting is selected, a missile flight time of 16 seconds is simulated. Engagements involving this long tracking time duration are conducted against targets moving with a crossing velocity of 5 milliradians per second. In the TOW training program this type of engagement is known as Task A.

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5 Department of the Army. TOW heavy antitank weapon system (Training Circular 23-23). Washington, D.C.: Author, July 1970.

If a "high-rate qualify" setting is selected, a missile flight time of 8 seconds is simulated. Engagements involving this short tracking time duration are conducted against targets moving with crossing velocities of either 15 or 25 milliradians per second. In the TOW training program, these engagements are known, respectively, as Task B and Task C.

Finally, during simulated firing practice, TOW blast effects may be simulated through the use of the M80 blast simulator. This simulator is installed in the missile simulation round. When the M70 training system is activated, the M80 simulator explodes and creates blast effects similar in kind to those created by firing a live TOW missile.

Typically, a TOW practice exercise consists of a number of simulated firing trials defined by a set of protocols summarized by an Instructional Firing Table. Table 1 presents a sample Instructional Firing Table. The firing table defines for each simulated firing the following information: the speed of the target, the qualification rate, the direction of movement for the target vehicle, and whether or not a blast simulator is employed during the trial.

As part of the initial procurement of the TOW system, a training program designed to teach operators the skills required for system use was developed and provided to the Army by the prime contractor for the system. Later during the test phase of the procurement, the TOW system was tested by the U.S. Army Infantry Board (USAIB). For this test, a prototype gunnery training program was developed by USAIB personnel with assistance from the prime contractor. During the service test, the prototype program was also evaluated. Based on the results of this evaluation, a 33 hour training program was developed.[6] This training program was designed to be implemented during Infantry AIT and up until October 1976, was taught at Fort Polk, LA.. At that time responsibility for the conduct of Continental United States (CONUS) TOW gunnery training was directly assumed by the USAIS and a course of instruction was established at Fort Benning, GA., under the direction of the Antiarmor and Mines Division, Weapons Department, USAIS. This course is also designed to be completed following AIT.

In the following sections the USAIS TOW gunnery training program is discussed in terms of its performance objectives, its practices (organization, instruction requirements, practice requirements) and its quality control procedures.

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6 McCluskey, M., Haggard, D., and Powers, T.. Survey of Army weapons training and weapons training devices. (ARI Research Memorandum 76-8). Arlington, VA: Army Research Institute for the Behavioral and Social Sciences, April 1976.

Table 1

SAMPLE INSTRUCTIONAL FIRING TABLE FOR A

SIMULATED TOW FIRING EXERCISE

Trial	Target Stationary[a]				Target Moving[a]							
					Task A: Target Speed is 5 Milliradians per Second				Task B: Target Speed is 15 Milliradians per Second			
	Range Switch Position	Launch Excursion Yes	Launch Excursion No	M70 Meter Score	Target Vehicle Direction	Launch Excursion Yes	Launch Excursion No	M70 Meter Score	Target Vehicle Direction	Launch Excursion Yes	Launch Excursion No	M70 Meter Score
1	High Rate	___	___	_____	L-R	___	___	___	L-R	___	___	_____
2	High Rate	___	___	_____	L-R	___	___	___	L-R	___	___	_____
3	High Rate	___	___	_____	L-R	___	___	___	L-R	___	___	_____
4	High Rate	___	___	_____	L-R	___	___	___	L-R	___	___	_____
5	High Rate	___	___	_____	L-R	___	___	___	L-R	___	___	_____
6	High Rate	___	___	_____	L-R	___	___	___	L-R	___	___	_____

a All trials are conducted without the blast simulator.

b Task A is conducted in the low rate mode.

c Task B is conducted in high rate mode.

USAIS TOW GUNNERY TRAINING OBJECTIVES

The POI and lesson plans for current USAIS TOW gunnery training were examined to identify the terminal and intermediate training objectives developed for this program. The objectives identified from this examination are presented in Appendix A and summerized in Table 2.

Based on (1) interviews with personnel responsible for implementing USAIS TOW gunnery training and (2) on field observations of training, it was found that the objectives for TOW range card preparation and tank identification have been eliminated from training. Interviews with the TOW training cadre indicated that these eliminations were implemented during a recent program modification effort (as discussed later in this report) in order to provide more time for conducting practical exercises, particularly exercises involving simulated missile firings. Training is now limited to the training objectives for the first seven task areas listed in Table 2.

In assessing the adequacy of the training defined by the objectives of a weapon system training program, it is necessary to determine the following:

- o To what extent the training objectives provide for the development of the knowledges and skills necessary for qualifying in the operation and use of the weapon system;

- o To what extent the training objectives provide for the development of the knowledges and skills necessary for employing the weapon system in combat.

In the remaining sections of this part of the report, the adequacy of the training objectives for the USAIS TOW gunnery training program is discussed in terms of the above considerations.

Qualification Tasks and USAIS Training. Qualification in the operation and use of the TOW weapon system is addressed in the USAIS TOW gunnery program by a two part post-training evaluation. This evaluation consists of:

- o A 3 hour, nine station, hands-on performance test covering assembly of the tactical TOW weapon system, conduct of the TOW system self-test, charging the TOW battery assembly, operation of the M70 training equipment, use of the TOW blast simulator, operation of the M89 target set, unloading a TOW missile, loading a TOW missile, and handling TOW missile misfires and hangfires.

Table 2

SUMMARY OF TRAINING OBJECTIVES FOR THE USAIS TOW GUNNERY TRAINING PROGRAM

Task Area	Training Objectives[a]
Introduction to TOW Weapon System	Place the TOW into operation. Assemble the TOW weapon system. Perform a system self-test. Load and unload an encased missile.
TOW Training Equipment	Place the TOW training equipment into operation. Operate the M70 training set. Load an M80 blast simulator. Place the M89 target set into operation.
Introduction to Crew Drill	Perform a TOW crew drill. Perform the TOW crew drill using the firing vehicle and missile carrier. Perform the crew drill on the APC TOW.
Gunnery Technique	Practice TOW gunnery technique.
Instructional Firing Table I	Engage a target. Prepare the TOW training equipment for operation and fire instructional firing Table I.
Instructional Firing Tables II through VIA	Practice TOW gunnery technique. Prepare the training equipment for operation and fire Tables II, III, IV, V, and VI. Engage a target during limited visibility (Table VIA).
Maintenance of TOW Weapon System and Battery Charging	Inspect the TOW to determine the status of maintenance. Charge the battery assembly for the TOW weapon system.
Range Card (TOW) Preparation	Prepare a TOW range card.
Tank Identification	Identify Warsaw Pact and Allied armored vehicles. Identify main groups of armor by suspension system, turret, cupola accessories, and armament. Identify vulnerable points and dead space on Warsaw Pact vehicles.

[a] Identified by training objective task statements. The complete objectives are presented in Appendix A of this report.

- o A firing test involving simulated missile firings using the TOW blast simulator during which the trainees each engage 30 laterally moving targets (10 moving with a 5 milliradian per second crossing velocity, 10 moving with a 15 milliradian per second crossing velocity, 10 moving with a 25 milliradian per second crossing velocity) under daylight illumination conditions.

Table 3 presents a comparison of the tasks covered by training objectives in the current USAIS program and the task areas covered by the post-training evaluation of the program. An inspection of this table shows that all but one of the task areas covered by the post-training evaluation are also covered by training objective tasks in the current USAIS TOW gunnery program. The task area not covered by a training objective concerns TOW missile misfires and hangfires. Field observations of training, however, indicate that this task area is addressed during that portion of training devoted to instruction in the operation of the TOW weapon system.

These results show with one exception that the training objectives for the USAIS TOW gunnery program provide for developing the knowledges and skills necessary for qualifying soldiers in the operation and use of the TOW system. For the task area not addressed by a specific training objective (TOW missile misfire and hangfire procedures), it was found that training does occur in the current program. Since this area is covered by the post-training evaluation, it would be appropriate to develop a specific objective for this area and include it in the objectives for the program. Having a specific objective will guarantee that this area will always be included during training. The development of an objective for missile misfire and hangfire procedures, however, presupposes the appropriateness of addressing this area during training, as well as during a post-training evaluation. If it is inappropriate to include this task during training, then it is also unnecessary to develop an objective to support its training. Further, in this case, the task area should be eliminated from the qualification procedure.

Combat Tasks and USAIS Training. The primary mission of the TOW squad in combat is to engage and defeat threat armor. Mission accomplishment depends significantly on the competence of the gunner to execute the engagement process. This process consists of the following phases:[7]

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[7] The description of the TOW engagement process is based on information found in the following source: Statz, J., Jr., and Etheridge, E. Personnel and training in battalion level force models (Technical Paper 10-76). Fort Leavenworth, KANS.: U.S. Army Combined Arms Combat Developments Activity, October 1976.

Table 3

COMPARISON OF TASKS COVERED BY TRAINING OBJECTIVES AND TASK AREAS COVERED BY THE POST-TRAINING EVALUATION OF THE CURRENT USAIS TOW GUNNERY PROGRAM

Training Task	Evaluation Task Area
Assemble the TOW weapon system.	Assembly of the tactical TOW weapon system.
Perform a system self-test.	Conduct of the TOW system self-test.
Load and unload an encased missile.	Loading a TOW missile. Unloading a TOW missile.
Operate the M70 training set.	Operation of the M70 training equipment.
Load an M80 blast simulator.	Use of the TOW blast simulator.
Place the M89 target set into operation.	Operation of the M89 target set.
Practice TOW gunnery technique.	Conduct of simulated missile firings.
Prepare the TOW training equipment for operation and fire instructional firing Table I.	Conduct of simulated missile firings.
Prepare the TOW training equipment for operation and fire Tables II, III, IV, V, and VI.	Conduct of simulated missile firings.
Charge the battery assembly for the TOW weapon system.	Charging of the TOW battery assembly.
Perform the TOW crew drill using the firing vehicle and the missile carrier.	-
Perform the crew drill on the APC TOW.	-
Inspect the TOW to determine the status of maintenance.	-
Engage a target during limited visibility (Table VIA).	-
-	Handling TOW missile misfires and hangfires.

1. System Deployment - Following the receipt of a mission requirement, the TOW system is deployed at an appropriate firing position and prepared for engagement. For both the ground and vehicle modes this involves system assembly and check out, establishing fields of fire, preparation of a TOW range card and system camouflage.

2. System Manning - Following deployment, the gunner mans the system. This involves assumption of a firing position consistent with the mode in which the system is being employed. The position selected should allow the gunner to comfortably manipulate the azimuth and elevation controls so that the entire field of fire is covered.

3. Visual Detection - After the system is manned, engagement is initiated with the visual detection of a candidate target. Detection is likely to be cued by such target characteristics as smoke, dust, and noise associated with target movement. On the modern battlefield candidate targets are armored fighting vehicles. Selected examples of these for Warsaw Pact and U. S. Forces are presented in Table 4. This table also presents the physical dimensions of these vehicles, as well as the vertical and horizontal visual angles subtended by the vehicle if viewed from the front at 1000 meters. Comparisons of these dimensions for U. S. and Warsaw Pact forces shows that Warsaw Pact vehicles are generally smaller in all dimensions than their U. S. Army counter-parts. For this reason, vertical and horizontal visual angles subtended by Warsaw Pact vehicle tend to be two or three minutes smaller than the angles subtended by comparable U. S. Army vehicles. These facts have two consequences for the visual detection phase. First, at long ranges, the visual detection of armored vehicles is likely to be a very difficult task. Second, the visual detection of threat armored vehicles is likely to be more difficult than the visual detection of the U. S. armored vehicles.

4. Target Acquisition - Once detected, the TOW gunner manipulates the azimuth and elevation controls of the system so that the system's optical sight is directly aligned with the candidate target and the sight's crosshairs are placed on the target's center-of-mass. This operation is called target acquisition. For stationary and on-coming targets this operation is likely to be less of a problem than for laterally

Table 4

DIMENSIONS OF AND VISUAL ANGLES (AT 1,000 METERS) SUBTENDED BY SELECTED WARSAW PACT AND U. S. ARMY VEHICLES[a]

Vehicle	Physical Dimensions (Meters) Height	Width	Length	Vertical Visual Angle at 1,000 Meters	Horizontal Visual Angle at 1,000 Meters
Soviet Army					
T-55 Tank	2.68	3.25	6.26	9.2'	11.2'
T-62 Tank	2.18	3.37	6.55	7.5'	11.6'
PT-76 Light Tank	2.23	3.14	6.85	7.7'	10.8'
BTR-60PB Combat Vehicle	2.29	2.81	7.31	7.9'	9.7'
BMP Combat Vehicle	1.85	3.10	6.51	6.4'	10.7'
BRDM Recon Vehicle	1.90	2.25	5.70	6.5'	7.7'
U. S. Army					
M60A1	3.28	3.63	6.95	11.3'	12.3'
M60A2	3.20	3.63	6.95	11.0'	12.5'
M551 Light Tank	3.00	2.80	6.30	10.3'	9.6'
M113 APC	2.20	2.69	4.68	7.6'	9.2'
M114 APC	2.33	2.33	4.46	8.0'	8.0'
LVTP-7 Landing Vehicle	3.14	3.20	7.93	10.8'	11.0'

[a] Based on data found in Pretty, R., and Archer, D. (Eds). Jane's Weapon Systems 1970-1971 (2nd ed.). New York: McGraw-Hill, 1970.

or obliquely moving targets. This is because targets in the latter case are more likely to require the gunner to track with the system than are targets in the former case.

5. Target Identification - Once acquired the gunner must decide if the candidate target is a threat or a friendly target. As discussed above, at long target ranges, friendly and threat targets present very small visual images when viewed by the unaided eye. Even with optical aides (such as 7x50 binoculars or the 13 power optical sight of the TOW system), these images are still so small that only gross target features are clearly recognizable. A further complicating factor in this situation is that friendly and threat armored vehicles are very similar in terms of shape, overall physical dimensions, and locations of external items, such as machine guns. When all of the factors are considered it is likely that the accurate discrimination of one type of armored vehicle from another may be quite difficult at long target ranges. For this reason, the problem of target identification is likely to be severe on the modern battlefield.

6. Target Range Determination - Concurrent with establishing the friend or threat nature of the target, the TOW gunner must determine the range to the candidate target. The principal advantage of the TOW system over threat armor is its great range capability. For targets out to about 3000 meters, hits can be achieved with this system with probabilities that exceed 50 percent.[8] At these ranges current threat armor cannot achieve hits with such high probabilities. For this reason, it is extremely important that the TOW gunner be able to accurately determine the range to a candidate target.

7. Decision to Fire - If the vehicle is identified as

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[8] Department of the Army. Range and lethality of U.S. and Soviet antiarmor weapons (TRADOC Bulletin 1 (U)). Washington, D.C.: Author, September 1975.

friendly, the engagement process is terminated. If it is identified as threat, the engagement process is continued. Once identified as a threat, the gunner must decide if the target is to be fired on. This decision is based on answers to a number of questions:

- o What is the engagement priority of the vehicle?
- o Is the vehicle within the engagement capabilities of the system?
- o Can system line-of-sight requirements be maintained within a high degree of probability during the firing sequence if engagement is continued?
- o Does the target's speed prevent continued engagement, i.e., is it moving too fast or too erratically to be smoothly tracked?
- o Is engagement consistent with the requirements of the mission?
- o Would continued engagement be too hazardous?
- o Are sufficient additional rounds available so that if additional firings are required to complete the immediate mission, they can be conducted?

If the decision is not to fire, the engagement process is terminated at this point. Otherwise, the process is continued.

8. Firing the TOW - The gunner activates the system by depressing the TOW trigger. Approximately 1.5 seconds later, the missile leaves the launch tube. Concurrently, the gunner continues to track the target, keeping the crosshairs of the optical sight on its center-of-mass. Tracking is continued until the missile impacts on the target or the run is aborted. In some instances, after the system has been activated, a misfire or a hangfire will occur. For these malfunctions the gunner initiates the appropriate immediate action procedure to correct the problem.

9. Damage Assessment - Following impact with the target, the shaped charge missile warhead explodes. Depending on the point and angle of impact, the

target may be completely destroyed, neutralized, or only minimally affected. The degree to which the target is affected is determined by a damage assessment. This procedure involves the continued visual observation of the target through the optical sight and a determination of the apparent effect of the missile impact.

Table 5 presents a list of the tasks performed by the gunner during the execution of the engagement process for the TOW system. These tasks were derived from an analysis of the description of the engagement process presented above. Because TOW target engagement is dependent on the successful completion of all of the tasks listed in Table 5, it follows that system training should address and provide for developing proficiency in conducting these tasks.

Table 6 lists the training objective tasks for the USAIS TOW gunnery program and the tasks performed during the execution of the TOW system engagement process. An inspection of this table shows that the USAIS TOW program training objectives address only seven of the 13 tasks involved in the execution of the TOW engagement process. These seven tasks are:

- o Assemble the TOW weapon system;
- o Check-out the assembled TOW weapon system;
- o Assume a firing position consistent with the mode of TOW deployment;
- o Align the TOW weapon system with a target;
- o Place the crosshairs of the optical sight on the target's center-of-mass;
- o Track a moving target;
- o Fire on and continue to track a target.

As discussed previously, however, current TOW training does include consideration of TOW missile misfire and hangfire procedures. Finally, tasks not addressed by the program training objectives or during the current training include the following:

- o Establish fields of fire;
- o Prepare a TOW range card;
- o Detect an armored fighting vehicle target;
- o Identify friendly armored fighting vehicles;

Table 5

GUNNER TASKS PERFORMED DURING THE EXECUTION OF THE TOW ENGAGEMENT PROCESS

Engagement Phase	
System Deployment	Assemble the TOW weapon system. Check-out the assembled TOW weapon system. Establish fields of fire. Prepare a TOW range card.
System Manning	Assume a firing position consistent with the mode of TOW deployment.
Visual Detection	Detect an armored fighting vehicle target.
Target Acquisition	Align the TOW system with a target. Place the cross hairs of the optical sight on the target's center-of-mass. Track a moving target.
Target Identification	Identify friendly armored fighting vehicles. Identify threat armored fighting vehicles. Discriminate between friendly and threat armored fighting vehicle.
Target Range Determination	Determine the range to a threat armored fighting vehicle.
Decision to Fire	Decide if a target should be fired on.
Firing the TOW	Fire on and continue to track a target. Employ the procedure for handling a TOW weapon system misfire or hangfire.
Damage Assessment	Assess the damage inflicted on a threat armored fighting vehicle by the impact of a TOW missile.

Table 6

TASKS PERFORMED DURING THE EXECUTION OF THE ENGAGEMENT PROCESS FOR THE TOW WEAPON SYSTEM
AND
TASKS ADDRESSED DURING THE USAIS TOW GUNNERY TRAINING PROGRAM

Task	Addressed in USAIS TOW Gunnery Program	Performed During Combat
System Deployment and Manning		
Assemble the TOW weapon system.	X	X
Check-out the assembled TOW weapon system.	X	X
Establish fields of fire.		X
Prepare a TOW range card.		X
Assume a firing position consistent with the mode of TOW deployment.	X	X
Visual Detection		
Detect an armored fighting vehicle target.		X
Target Identification		
Identify friendly armored fighting vehicles.		X
Identify threat armored fighting vehicles.		X
Discriminate between friendly and threat armored fighting vehicles.		X
Target Range Determination		
Determine the range to a threat armored fighting vehicle.		X
Target Acquisition, Decision to Fire, and Firing the TOW		
Align the TOW weapon system with a target.	X	X
Place the cross hairs of the optical sight on the target's center-of-mass.	X	X
Track a moving target.	X	X
Decide if a target should be fired on.		X
Fire on and continue to track a target.	X	X
Employ the procedure for handling a TOW weapon system misfire or hangfire.		X
Damage Assessment		
Assess the damage inflicted on a threat armored fighting vehicle by the impact of a TOW missile.		X
TOW Training Equipment		
Place TOW training equipment into operation.	X	
TOW Crew Drill		
Perform the TOW crew drill.	X	
Maintenance of TOW Weapon System and Battery Charging		
Inspect the TOW to determine the status of maintenance	X	
Charge the battery assembly for the TOW weapon system.	X	

- o Identify threat armored fighting vehicles;
- o Discriminate between friendly and threat armored fighting vehicles;
- o Determine the range to a threat armored fighting vehicle;
- o Decide if a target should be fired on;
- o Assess the damage inflicted on a threat armored fighting vehicle by the impact of a TOW missile.

Because these tasks are critical to the completion of the TOW engagement process, provision should be made for training in these tasks.

Summary of Training Objectives Analysis. The analysis of the training objectives for the USAIS TOW gunnery program shows with one exception that the objectives address the knowledges and skills necessary for qualifying in the operation and use of the TOW weapon system. The objectives, however, incompletely address the knowledges and skills required to complete the TOW engagement process in combat. For this reason, it should not be expected that soldiers who complete the USAIS TOW gunnery training program and qualify in the operation and use of the TOW system will be able to successfully execute the TOW engagement process in combat. In this respect, a gap exists between the knowledges and skills covered during training and those required to employ the system in combat. This gap may be closed if the training objectives for the USAIS program (and therefore, the training activities derived from these objectives) are augmented with objectives that address the areas currently not covered by the program.

USAIS TOW GUNNERY TRAINING PRACTICES

During August 1976, to prepare for implementing TOW gunnery training, the USAIS Antiarmor and Mines Division developed a 5 day, 31 hour training program designed to provide instruction in:

- o TOW system assembly, operation, and maintenance;
- o TOW gunnery techniques;
- o TOW crew duties;
- o Tank identification;
- o Range card preparation;
- o Instructional firing.

As discussed above, live missiles are not employed during firing practice. Instead, simulated firings using the M70 training set are conducted during practice. Therefore, instruction in the operation and use of the M70 training equipment was also included in USAIS program. A total of 21.5 hours of program time were allocated for gunnery instruction and practice. Additionally, 7.5 hours of program time were allocated for a post-training qualification evaluation consisting of a 30 minute written test, a 3 hour hands-on performance test, and a 4 hour qualification firing test. Following this evaluation, 2 hours were allocated for course graduation during which the soldier with the highest qualification score was allowed to fire a live TOW missile.

Appendix B presents a summary of this gunnery program. An examination of the summary yields the following findings:

- o On each day of instruction (Days 1, 2, and 3), training time is distributed between instruction designed to present information and instructional firing. However, the proportion of time allocated to these catagories varies across training days. On Day 1, the emphasis is on instruction designed to present basic information, while on Days 2 and 3 the emphasis is on instructional firings.

- o Over all training days, the majority of training is conducted using practical exercises with the majority of these exercises involving simulated firings.

- o The primary instructional medium for the TOW system in this program is actual equipment supported by the use of the M70 training device.

- o Over all simulated firing exercises, the emphasis is on the engagement of slow moving (5 milliradian per second) targets.

- o During instructional firing, only 11 percent of the target engagements are conducted at night.

- o During instructional firing, blast simulation is employed during 30 percent of the simulated firings.

- o During instructional firing, only 11 percent of the targets engaged, moved unpredictably.

The gunnery training program discussed above was implemented at Fort Benning, Georgia on 8 October 1976. It was used, unchanged, through 27 January 1977. Data obtained from the Antiarmor and Mines Division, Weapons Department, USAIS, show that during this period, a total of 305 soldiers completed this gunnery training. Of these, 62

percent (189 soldiers) met the minimum qualification requirements. As shown in Table 7, the majority of these soldiers (44 percent) qualified at the lowest level of qualification, i.e., 2ND Class Gunner. In response to this situation, on 28 January 1977, a series of course changes were initiated by USAIS primarily with respect to instructional firing. These changes were designed to improve TOW gunnery instruction and therefore, increase the number and quality of qualified TOW gunners. Based on an evaluation of the effects of these changes, a modified version of the August 1976 USAIS TOW gunnery program was implemented on 15 April 1977. In this program, a total of 19.4 hours are reserved for training, while 9 hours are allocated for a post-training proficiency evaluation and graduation. Appendix C presents a summary of the modified program.

A comparison of the AUGUST 76 and 15 APRIL 77 USAIS TOW gunnery programs shows that the modification was characterized by the following changes:

- o All instruction designed to present information was incorporated into Day 1 training. The remaining training days were reserved for instructional firing.

- o The number of areas addressed during training was reduced from 12 to 11. Two areas were eliminated (Tank Identification and Range Card (TOW) Preparation) and one was added (TOW Training Equipment: Practical Exercise in the Operation and Use).

- o The time allocated for instruction in gunnery technique and maintenance was reduced.

- o The time allocated for the TOW crew drill was increased from .8 to 2.8 hours.

- o The amount of time the lecture method was employed, was increased from 1.3 to 1.9 hours, while the amount of time allocated for the lecture/demonstration method was decreased from 2.5 to 1.3 hours. The use of the conference method was discontinued. The amount of time practical exercises were conducted, was decreased from 17.3 to 16.2 hours.

- o The total number of instructional firings was increased from 98 to 110. Further, more emphasis was given to engagements involving slow moving (5 milliradian per second) targets by increasing the number of these from 50 to 68.

- o The primary instructional media for the TOW system remained actual equipment supported by the use of the M70 training equipment. Because two content areas were

Table 7

NUMBER AND PERCENTAGE OF SOLDIERS WHO QUALIFIED AND FAILED TO QUALIFY UNDER THE AUGUST 1976 TOW GUNNERY PROGRAM: FROM 8 OCTOBER THROUGH 27 JANUARY 1977

Qualification	Number	Percentage
Unqualified	116	38
Qualified	189	62
2ND Class Gunner	136	44
1ST Class Gunner	48	16
Expert Gunner	5	2
Total	305	100

dropped, the use of charts was reduced and the use of the chalk board for presenting information was discontinued.

- o The written portion of the post-training evaluation was eliminated. Completion of the hands-on performance test was moved from Day 4 to Day 3.

Consideration of the changes described above shows that the program modification effort accomplished the following. First, all of the instruction involving the presentation of information to trainees was consolidated into the first day of training. This was done by eliminating training in some areas, by moving training for other areas to the first day of the training sequence, and by reducing the amount of training time allocated to selected areas. Second, the amount and kind of target engagement practice for the TOW system was increased. This was accomplished by increasing the total number of instructional firings conducted during training and by giving more emphasis to target engagements involving slow moving targets.

Table 8 (which is based on data obtained from the Antiarmor and Mines Division, Weapons Department, USAIS) shows the number and percentage of soldiers who qualified and failed to qualify under the 15 APRIL 77 TOW program, as this was implemented during the period beginning 15 April 1977 and ending 19 May 1977. During this time, a total of 178 soldiers completed training. Of these 87 percent (155 soldiers) met the minimum qualification requirements. This represents an improvement over the old program which had a qualification rate of 62 percent. Further, for each qualification level (2ND Class, 1ST Class, and Expert Gunner) there was an increase in the percentage of personnel qualifying. (See Table 9). These results, therefore, show that the modified TOW gunnery program (as discussed above) is a more effective way of instructing soldiers in the operation and use of the TOW weapon system than the August 76 training program.

USAIS TOW GUNNERY PROGRAM QUALITY CONTROL PROCEDURES

A training program can be viewed as a way of increasing the reliability of the human in a man-machine system. Usually, the quality of the trained person is assessed at the termination of training. This assessment typically involves completion of a test designed to measure the end-of-training capabilities of the individual with respect to the instruction and practice requirements met during training.

The post-training proficiency evaluation for the August 1976 TOW gunnery program involves the completion of the following examinations:

- o A 30 minute written test covering the operation and use of the TOW weapon system;

Table 8

NUMBER AND PERCENTAGE OF SOLDIERS WHO QUALIFIED AND FAILED TO QUALIFY UNDER THE 15 APRIL 1977 GUNNERY PROGRAM: FROM 15 APRIL THROUGH 19 MAY 1977

Qualification	Number	Percentage
Unqualified	23	13
Qualified	155	87
2ND Class Gunner	89	50
1ST Class Gunner	48	27
Expert Gunner	18	10
Total	178	100

Table 9

PERCENTAGE OF SOLDIERS WHO QUALIFIED AT EACH QUALIFICATION LEVEL UNDER THE AUGUST 1976 AND 15 APRIL 1977 USAIS TOW GUNNERY PROGRAMS

Qualification Level	August 1976 Program	15 April 1977 Program
2ND Class Gunner	44	50
1ST Class Gunner	16	27
Expert Gunner	2	10
Total	62	87

- A 3 hour, nine station, hands-on performance test covering assembly of the tactical TOW weapon system self-test, charging the TOW battery assembly, operation of the M70 training equipment, use of the TOW blast simulator, operation of the M89 target set, unloading a TOW missile, loading a TOW missile and handling TOW missile misfires and hangfires;

- A hands-on, simulated firing test requiring the engagement of 30 laterally moving targets (10 moving at 5 milliradians per second, 10 moving at 15 milliradians per second and 10 moving at 25 milliradians per second) under daylight illumination conditions using the M70 training set and the TOW blast simulator.

To complete this program successfully, trainees are required to answer correctly 70 percent of the written test questions, achieve a score of 70 percent at each performance test station, and achieve minimum engagement scores of 55 percent for the 5 and 25 milliradian per second target engagements and 75 percent for the 15 milliradian per second engagements during qualification firing. Additionally, applying the standards stated in Table 10, trainees are assigned (on the basis of their firing scores) one of the following qualification ratings: Expert Gunner, 1ST Class Gunner, 2ND Class Gunner and Unqualified as Gunner.

With the implementation of the 15 APRIL 77 TOW gunnery program, the written portion of the evaluation was discontinued. The other components of the post-training evaluation were unchanged. The information provided by this evaluation serves as the basis for quality control in this and the initial gunnery training program.

The quality of the personnel produced by a training program is reflected in terms of their post-training proficiency, as well as their capability to perform once they are on the job. Therefore, control of program quality can be accomplished in at least three ways:

- By assessment of product quality as a function of time with respect to the proportion of personnel whose post-training proficiency meets minimum success standards.

- By assessment of product quality as a function of time with respect to average post-training proficiency of the personnel who complete the training program.

- By assessment of the on-the-job performance of the personnel who have completed training.

Table 10

QUALIFICATION STANDARDS FOR TOW GUNNERY TRAINING[a]

Target Engagement Task	Unqualified as Gunner	2ND Class Gunner	1ST Class Gunner	Expert Gunner
5 Milliradians Per Second	0-54.9%	55%-64.9%	65%-74.9%	75%-89.8%
15 Milliradians Per Second	0-74.9%	75%-82.5%	82.6%-89.9%	90%-100%
25 Milliradians Per Second	0-54.9%	55%-64.9%	65%-74.9%	75%-89.8%

[a] To determine a trainee's qualification rating for a particular target engagement task, find the qualification classification corresponding to his engagement score for that task. The trainee's overall qualification rating is the lowest task rating.

Discussions with knowledgable members of the Antiarmor and Mine Division, revealed that at present quality control for this program is accomplished only by the first method discussed above. In employing this method the following procedure is used:

> For each class of soldiers completing the gunnery training program, the overall qualification rating of each soldier is derived as indicated in Table 10. Next, for this group the number of individuals with each overall qualification rating is determined. This information is incorporated into a data base for all previous classes. Next, the percentage of soldiers qualifying at each rating through the current training group is computed. These results are entered into a table which presents the proportion of personnel who have qualified at each rating as a function of successive TOW training classes. Periodic inspections of this table indicate to what extent TOW gunnery product quality is consistent. If the cumulative proportions appear to remain relatively constant over time, quality is considered to be consistent. If the percentages within selected catagories are judged to be too high or low, program changes designed to adjust the percentages within selected catagories to acceptable levels are tested and evaluated. If the program changes are judged to be successful, they are implemented.

As discussed above, this method is the only procedure currently employed to evaluate TOW program quality. Members of the Antiarmor and Mines Division were asked if any other method is ever employed to assess gunnery quality. It was reported, that on occasion, personnel from the USAIS have soldiers who have just completed the gunnery program, demonstrate that their overall qualification rating is, in fact, valid. In these instances, these soldiers complete for a second time the M70 qualification simulated firing test. Based on the results of this test, a second overall qualification rating is determined for each soldier and compared with his first qualification rating. If the two sets of ratings are found to generally agree, qualification ratings are judged valid and the program is judged as adequate. On the other hand, if the two sets of ratings tend not to agree, an assessment is implemented to determine the reason for the discrepancy.

Finally, personnel from the Antiarmor and Mines Division were asked if formal feedback from units receiving personnel trained by the USAIS TOW program is ever directly received that indicates to what extent these personnel are capable of employing the TOW system to engage targets. It was indicated that this never happens because the Antiarmor and Mines Division has no formal mechanism set up for obtaining this information directly from units in the field. However, these

personnel mentioned that this type of information would be useful in assessing their program.

DISCUSSION

The ARI is currently conducting research to identify improvements and develop cost-effective alternatives for TOW gunnery training. A necessary prerequisite for accomplishing these tasks is the documentation and analysis of current gunnery training for this system. As part of its support to ARI, Mellonics was tasked to perform the required documentation and analysis. This section discusses the results of the documentation and analysis and their implications for the ARI TEA research for the TOW weapon system.

USAIS TOW GUNNERY TRAINING

The purpose of the current USAIS TOW gunnery program is to qualify military personnel in the operation and use of the TOW system. An analysis of the overlap between program training tasks and post-training evaluation tasks revealed that substantial commonality exists between the two sets of tasks. This indicates that program training generally provides for accomplishing the above stated program purpose. However, it was found that many of the target engagement tasks critical for effective combat use of the system are not covered by current training. In this respect, a gap exists between the training provided by the current TOW gunnery program and the training required for effectively using the system in combat.

Analysis of the training practices for the USAIS program revealed that the majority of total program training time (16.2 hours) is allocated to the conduct of practical exercises. Most of these exercises consist of instructional firings with the majority of these firings (68 out of 110 firings) involving slow moving (5 milliradian per second) cooperative targets. The analysis also shows that the primary instructional medium for the program is the actual TOW system and its associated training equipment. Together, these results indicate that the instructional emphasis of the program is the acquisition of the basic skills required to track and fire on targets, i.e., the development of proficiency in TOW gunnery fundamentals. This is accomplished via substantial use of the actual TOW system supported by the M70 training system.

Finally, it was discovered that program quality control is only accomplished through intra-program means. Interviews with program cadre revealed that summary statistics indicating the percentage of personnel qualifying (at each of three levels of proficiency) and not qualifying after the completion of training are used as the basis for measuring program quality. Periodic assessments of this information serve as the basis for decisions to make changes to the program. It

was also found that no formal procedures now exist to obtain direct feedback from units receiving USAIS TOW qualified gunners with respect to their on-the-job missile firing proficiency.

In summary, the above discussion indicates that the USAIS TOW gunnery training program is designed primarily to produce gunners proficient in system operation and the application of the fundamentals of TOW gunnery. For this reason, the USAIS program can, at best, be characterized as a preparatory weapons training program. In such programs, trainees are taught only the skills necessary for the operation of their weapons so that these weapons can be fired with satisfactory consistency.[9]

The results also show that the USAIS program employs minimal quality control procedures. These provide only for the assessment of intra-program quality and, then, just in gross terms. For this reason, the identification of program weaknesses is likely to be somewhat inefficient. Further, because no formal procedures exist for determining the on-the-job adequacy of USAIS gunnery graduates, it is not possible for personnel administering the USAIS course to directly establish to what extent the USAIS program prepares its graduates to perform as TOW gunners in the field.

ANALYSIS IMPLICATIONS

Training. Because the emphasis of TOW gunnery training is on the development of the basic skills necessary for system operation, a question arises concerning the extent to which this training can be expected to transfer to combat. A comparison of TOW target engagement tasks with the current training implemented during completion of the USAIS TOW gunnery program showed that few of the tasks involved in target engagement process are addressed by the USAIS program. As discussed in the results section of this report, the current program is a modification of the initial TOW gunnery program implemented at Fort Benning, Georgia. In the initial program, target identification and range determination (two important components of the engagement process) were addressed. With the implementation of the modified program, these topics have been dropped because of lack of program time. However, qualified TOW gunners should be proficient in these tasks. For this reason, some provision should be made for instruction in these subject areas. Further, in neither the current or original USAIS

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9 Jacobs, T., Salter, J. and Christie, C.. The effects on training requirements of the physical and performance characteristics of weapons. (HUMRRO Technical Report 74-10). Alexandria, VA: Human Resource Research Organization, June 1974.

program was there any consideration of establishing fields of fire, vehicular target detection, range determination, the principles of damage assessment, or decision-making for TOW target engagement. These are also intergal components of the target engagement process. For this reason training should also be conducted for these topics.

Additionally, it is appropriate for the TOW gunner to be practiced in engaging targets that have properties similar to those likely to be encountered during combat. Because of the emphasis of the current USAIS TOW gunnery program, as well as the limitations imposed by the TOW training equipment, the target engagements conducted during this training are relatively sterile events. Targets are not realistic, since they are not armored vehicles. Targets are generally cooperative, in that they move along predictable paths either from the left to the right or from the right to the left. In no instance do targets advance or retreat from the trainees during training engagements. Oblique profiles are never presented. As shown in the summary of current training practices, most of the simulated firings are conducted during daylight hours; few of the firings involve intermittently moving targets; and most target engagements involve relatively slow moving targets.[10] Obviously these conditions are conducive to the development and practice of basic gunnery skills. However, because of this non-realism (sterility), it cannot be expected that trainees will be adequately prepared to track and fire on combat targets.

Preparation for firing on such targets can be obtained through specific practice sessions designed to provide the trainee opportunities to engage realistic targets moving as they might in combat. In particular, it would be appropriate to have trainees engage uncooperative, erratically moving tanks and armored personnel carriers; obscured by dust, smoke, vegetation, or terrain features; advancing, retreating, and obliquely moving targets. Additionally, it would be appropriate to provide substantial practice under conditions of low illumination levels. Currently, the USAIS TOW gunnery training program includes no specific practice sessions that involve the engagement of combat-like targets. Because such practice is one way of extending the application of gunnery fundamentals to more complex, more demanding engagement situations, it would be appropriate to augment the preparatory gunnery practice of this program with extensive amounts of combat related practice. In this way, graduates of the program would be better prepared to engage and successfully defeat enemy targets on the modern battlefield.

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These conditions have also been noted by Swezey, R., Chitwood, T., Jr., Easley, D., and Waite, B.. Implications for TOW Gunnery Training Development (Final Report). Springfield, VA: Mellonics Systems Development Division, Litton Systems, Inc., October 1977.

Quality Control. As discussed above, the USAIS TOW gunnery program provides only for a limited assessment of internal quality. Program quality is reflected by the percentage of personnel qualifying at each level of gunnery proficiency (Expert, 1ST Class, and 2ND Class Gunners) and by the percentage of personnel who fail to qualify. Comparisons of these percentages for current TOW gunnery classes with those of past classes is the means by which training adequacy is determined. If the two sets of percentages are judged not to be significantly different, current training is judged to be adequate. Otherwise, it is judged to be inadequate. In this case, an investigation is implemented to determine basis for observed deviations. The problem with this procedure is that while it provides for identifying quality problems, it does not provide for identifying the nature of these problems. However, this deficiency can be remedied by the collection and maintenance of detailed class records reflecting class performance at each stage of training and evaluation. When a problem is identified, these records can be inspected and evaluated to determine the exact basis for the identified problem. Specific weaknesses for specific classes can be determined and appropriate remedial action can be taken to ensure that for future classes these problems are addressed and solutions implemented so that they cease to be a problem.

It was also noted above that no provision currently exists for assessing the extent to which program graduates are capable of meeting the TOW gunnery requirements of their post-training assignments. This is viewed as a significant limitation of the program. Unless program graduates possess the gunnery skills required for on-the-job success, they will not be able to perform their new assignments satisfactorily (at least initially). Therefore, it would be appropriate to establish a procedure for obtaining information reflecting on-the-job proficiency. Appropriate information to be collected in this case would be:

- o Field comments of commanders;
- o Amount and kinds of remedial training needed for each graduate in order to be able to minimally perform in their post-training assignments;
- o Annual firing scores (both live and M70 meter scores) for the TOW.

Once collected, this information could be correlated with appropriate training and evaluation data. An analysis of this information would provide a basis for establishing the quality of program graduates with respect to job preparation. Additionally, such an analysis could lead to the identification of short falls in the training program, i.e., areas for which job preparation was too little or totally absent.

CONCLUSIONS

The primary goal of all training in the U.S. Army is to prepare for winning the first battle of the next war. To win this battle, U.S. forces from the onset of hostilities must be able to use their weapons proficiently so that combat effectiveness is maximized. For this reason, weapon system training should be geared to the production of personnel so proficient in the use of their designated weapons, that they are capable of entering battle on a moments' notice without additional systems training.

Long range antitank guided missile (ATGM) systems are among the dominant weapons on the modern battlefield. Their combat effectiveness is a function of basic system capabilities, the tactics and techniques of employment, and most notable, the proficiency of the gunners employing the systems. The primary ATGM system of U.S. forces is the TOW heavy antitank weapon. Because of its importance, it is essential that TOW gunners be able to proficiently perform each task necessary for successfully engaging the primary target for the system, armored fighting vehicles. Otherwise, the combat effectiveness of units supported by this system may not be fully realized. Well defined and implemented gunnery training programs are the means by which proficient TOW gunners are produced. In this section of the report, conclusions derived from the documentation and analysis of the USAIS TOW gunnery program are presented:

- The USAIS TOW gunnery program is a preparatory weapons training program. It emphasizes only the tracking and firing aspects of the TOW engagement process. Because of the preparatory emphasis of the USAIS TOW gunnery program, it can not be expected that graduates of this program will be able to effectively complete the engagement process for the TOW weapon system unless they receive training in the areas of armored vehicle detection and identification, establishing fields of fire, range estimation, target engagement decision-making, and damage assessment. Additionally, trainees must be provided with opportunities to engage targets that have properties similar to those likely to be encountered during combat.

- The quality control procedures for the USAIS TOW gunnery program are limited to the assessment of intra-program quality at a very gross level. The development and maintenance of detailed records for each stage of training and evaluation for each USAIS gunnery class would likely provide a data base for identifying the basis for deviations in internal program quality.

- Establishment of formal procedures for gathering data directly indicating on-the-job proficiency of USAIS TOW gunnery graduates would provide a basis for assessing the adequacy of the program with respect to job preparation as this relates to TOW gunnery by those personnel responsible for administering the USAIS program.

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APPENDIX A

USAIS TOW GUNNERY TRAINING PROGRAM TRAINING OBJECTIVES

Table A-1

TRAINING OBJECTIVE AND INTERMEDIATE TRAINING OBJECTIVES FOR "INTRODUCTION TO TOW WEAPON SYSTEM"

Training Objective

Task:	Place the TOW into operation.
Condition:	Acting as a TOW crew member during daylight on a TOW tracking range; given a tripod, traversing unit, optical sight, battery assembly, missile guidance set, and missile simulation round.
Training Standard:	Squad Leader - Prepare and level the tripod; Install the optical sight. Assistant Gunner - Install the traversing unit; Install the launch tube; Load a round. Gunner - Connect the missile guidance set; Perform a system self-test IAW TC 23-23 and TM 9-1425-470-12. Driver - Resupply ammunition and provide local security.

Intermediate Training Objectives

Intermediate Training Objective I

Task:	Assemble the TOW weapon system.
Condition:	On a TOW tracking range during daylight; given a tripod, traversing unit, optical sight, battery assembly, missile guidance set, and missile simulation round.
Training Standard:	Properly assemble and name the six components of the TOW weapon system IAW TC 23-23.

Intermediate Training Objective II

Task:	Perform a system self-test.
Condition:	On a TOW tracking range during daylight; given a TOW weapon system.
Training Standard:	Perform a system self-test and boresight the TOW weapon system. Explain what is checked at each check point during the system self-test and what units will be replaced if an "in-band" or "center-band" reading is not recorded. The self-test must be 100% correct.

Intermediate Training Objective III

Task:	Load and unload an encased missile.
Condition:	On a TOW tracking range during daylight; given a TOW weapon system and a missile simulation round.
Training Standard:	Loading an Encased Missile - Inspect the encased missile; remove the forward handling ring and electrical connector cap; insure that the TOW azimuth and elevation locks are locked; raise the bridge clamp; and load the encased missile. Unloading an Encased Missile - Lock the azimuth and elevation locks; raise the bridge clamp; remove the encased missile, insuring that the warhead is pointed down range; and replace the forward handling ring and electrical connector cap IAW Training Circular 23-23.

Table A-2

TRAINING OBJECTIVE AND INTERMEDIATE TRAINING OBJECTIVES FOR "TOW TRAINING EQUIPMENT"

Training Objective

Task:	Place the TOW training equipment into operation.
Condition:	On a TOW tracking range acting as a TOW crew member during daylight; given a tripod, traversing unit, optical sight with battery assembly, missile guidance set, missile simulation round, launch tube, instructor console with battery assembly, target set and a vehicle with a 24 volt system.
Training Standard:	Squad Leader/Scorer - Record the gunner's score after completion of a tracking exercise; Reset the score and battery meter on the instructor console for another exercise. Assistant Gunner - Load and arm the missile simulation round. Gunner - Insure that the TOW is properly assembled and that it passes a system self-test; Insure that all cables are correctly connected; Insure that all switches are correctly positioned; Insute that the training equipment is operational and safe. Driver - Assemble and operate the target set IAW Training Circular 23-23.

Intermediate Training Objectives

Intermediate Training Objective I

Task:	Operate the M70 training set.
Condition:	During a field tracking exercise with a target traveling at different speeds over varied terrain, during daylight; given a complete M70 training set, a TOW weapon system, and a target set mounted on a target vehicle.
Training Standard:	Operate the M70 training set well enough to conduct and score a tracking exercise.

Intermediate Training Objective II

Task:	Load an M80 blast simulator.
Condition:	During a tracking exercise with a target traveling at different speeds over varied terrain; given a TOW weapon system, an M70 training set, and an M80 blast simulator.
Training Standard:	Observe all safety precautions and use the correct procedures for loading the blast simulator during a tracking exercise.

Intermediate Training Objective III

Task:	Place the M89 target set into operation.
Condition:	On a TOW tracking range during daylight; given a complete M89 target set, an M151A1 vehicle, and a TOW weapon system.
Training Standard:	Place the M89 target set into operation and conduct a tracking exercise using the correct procedures and observing necessary safety precautions.

Table A-3

TRAINING OBJECTIVE AND INTERMEDIATE TRAINING OBJECTIVES FOR "INTRODUCTION TO CREW DRILL"

Training Objective

Task: Perform a TOW crew drill.

Condition: On a TOW field tracking exercise acting as a TOW crew member during daylight; given the TOW weapon system, M151A2 firing vehicle, M151A2 missile carrier, and a M113 TOW.

Training Standard: IAW TC 23-23, Chapters 7 & 8
Squad Leader - Select targets and direct fire.
Assistant Gunner - Prepare the round; Check the backclast area; Load the missile; Arm the weapon.
Gunner - Perform checks for positions 1 and 7 on the Missile Guidance Set; Acquire the target; Fire the missile.
Driver (M151A2) - Provide local security; Camouflage the vehicle; Prepare subsequent missiles for firing.
Driver (M113) - Secure the vehicle radio antenna; Camouflage the vehicle.

Intermediate Training Objectives

Intermediate Training Objective I

Task: Perform the TOW crew drill using the firing vehicle and the missile carrier.

Condition: As a TOW squad; given a TOW firing vehicle, a missile carrier, a missile simulation round, and a TOW weapon system.

Training Standard: The squad must insure that the equipment is operational, a system self-test is made and that the duties of each squad member are executed IAW TC 23-23, Chapter 8, Section II.

Intermediate Training Objective II

Task: Perform the crew drill on the APC TOW.

Condition: As a TOW squad; given an APC TOW, a missile simulation round, and a TOW weapon system.

Training Standard: The squad will insure that all equipment is operational, a system self-test is made, and the duties of each squad member are executed IAW TC 23-23, Chapter 8, Section III.

Table A-4

TRAINING OBJECTIVE FOR "GUNNERY TECHNIQUE"

Training Objective	
Task:	Practice TOW gunnery technique.
Condition:	Acting as a TOW gunner using the TOW weapon system and target set in a daylight simulated tracking exercise on a TOW range.
Training Standard:	Assume the correct firing position; sight on the target board; aim at the designated point on the target board; manipulate the control knobs for vertical and horizontal adjustment; shift the sitht; use breath control; and track the target.

Table A-5

TRAINING OBJECTIVE AND INTERMEDIATE TRAINING OBJECTIVE FOR "INSTRUCTIONAL FIRING TABLE I"

Training Objective

Task:	Engage a target.
Condition:	Acting as a TOW gunner using the TOW weapon system and the M70 Training Set during a daylight familiarization tracking exercise on a TOW tracking range.
Training Standard:	Take a correct firing position; sight and aim; manipulate the control knobs; use breath control; and track the target. Achieve a percentage score of 55% or better for low rate qualify tasks and 75% or better for high rate qualify tasks, IAW TC 23-23, Chapter 8.

Intermediate Training Objective

Task:	Prepare the TOW taining equipment for operation and fire instructional firing Table I.
Condition:	On a TOW tracking range during daylight; given the TOW weapon system, an instructor console, a target set, and an M151A2 vehicle.
Training Standard:	Operate TOW weapon system, conduct a field tracking exercise and complete instructional firing Table I.

Table A-6

TRAINING OBJECTIVE AND INTERMEDIATE TRAINING OBJECTIVES FOR "INSTRUCTIONAL FIRING TABLES II THROUGH VIA"

Training Objective

Task:	Practice TOW gunnery technique.
Condition:	Acting as a TOW gunner using the TOW weapon system and target set in a daylight simulated tracking exercise on a TOW tracking range.
Training Standard:	Assume the correct firing position; sight on the target board; aim at the designated point on the target board; manipulate the control knobs; use breath control; and track the target.

Intermediate Training Objectives

Intermediate Training Objective I

Task:	Prepare the training equipment for operation and fire Tables II, III, IV, V and VI.
Condition:	On a field tracking exercise using a target vehicle moving at various speeds during daylight; given a TOW weapon system, an M70 Trainer Set, and M80 Blast Simulators.
Training Standard:	Engage moving targets using correct gunnery technique; develop proficiency in engaging targets; and assume correct firing positions. Achieve a percentage score of 55% or better for low rate qualify tasks and a percentage sum of 75% or better for high rate qualify tasks.

Intermediate Training Objective II

Task:	Engage a target during limited visibility (Table VIA).
Condition:	Acting as a TOW gunner on a TOW tracking range at night; given a TOW Launcher, an M70 Training Set, a Target Set mounted on a vehicle and illumination from either 81mm mortar rounds, M203 grenade rounds, hand held flares or tank searchlights.
Training Standard:	Assume the correct firing position; sight and aim at the target; manipulate the firing knobs; use breath control; and track the target.

Table A-7

TRAINING OBJECTIVE AND INTERMEDIATE TRAINING OBJECTIVES FOR "MAINTENANCE OF TOW WEAPON SYSTEM AND BATTERY CHARGING"

Training Objective

Task:	Inspect the TOW to determine the status of maintenance.
Condition:	Acting as a squad leader; given the responsibility of maintaining the TOW weapon system in an operationally ready status, a fully assembled M220A1 TOW Launcher, with its Log Book, TM 38-750, TM 9-1425-470-ESC and DA Form 2404.
Training Standard:	Perform the inspection IAW paragraphs 2-41 and 3-4 through 3-7, TM 9-1425-470-12. Determine whether the batteries are charged and maintained IAW TM 9-6130-470-12. Check the DA Form 2404 to determine whether an ESC has been performed at least once a quarter IAW TM 9-1425470-ESC and Ch 3, TM 38-750. The log book must be present and contain DA Forms 2408 and 2409.

Intermediate Training Objective

Task:	Charge the battery assembly for the TOW weapon system.
Condition:	On a TOW tracking range during daylight; given a battery charger and battery assembly.
Training Standard:	Conduct an operational check of the battery charger; mount the battery on the charger; start charging; and tag the battery with the date it was charged.

Table A-8

TRAINING OBJECTIVE FOR "RANGE CARD (TOW) PREPARATION"

Training Objective	
Task:	Prepare a TOW range card.
Condition:	Acting as a squad leader during a field tracking exercise during daylight.
Training Standard:	The Range Card must indicate the maximum range line, dead space, sectors of fire, distance to and from covered areas, location and distance to targets reference points within range, the unit designation, the time and date prepared, and the weapon position plotted from a known point IAW TC 7-24.

Table A-9

TRAINING OBJECTIVE AND INTERMEDIATE TRAINING OBJECTIVES FOR "TANK IDENTIFICATION"

Training Objective

Task:	Identify Warsaw Pact and Allied armored vehicles.
Condition:	Acting as a squad leader using the four step method of tank identification on a TOW tracking range during daylight; given a range terrain board, 6x30 binoculars and tank models.
Training Standard:	Accurately identify a minimum of 5 tank models within 20 minutes based on an analysis of the suspension, turret, cupola accessories, and armament of the models.

Intermediate Training Objectives

Intermediate Training Objective I

Task:	Identify main groups of armor by suspension system, turret, cupola accessories and armament.
Condition:	As a TOW gunner on a range during daylight; given scale models of tanks, binoculars and terrain board.
Training Standard:	Accurately identify tanks as to their friend or threat nature.

Intermediate Training Objective II

Task:	Identify vulnerable points and dead space on Warsaw Pact vehicles.
Condition:	Acting as a TOW gunner on a TOW tracking range during daylight; given 4x4 tank identification boards of Warsaw Pact armor.
Training Standard:	Identify vulnerable points and dead space on Warsaw Pact armor and be correct in 85% of the identifications.

APPENDIX B

SUMMARY OF THE USAIS TOW GUNNERY TRAINING PROGRAM
AUGUST 1976 VERSION

Table B-1

USAIS TOW GUNNERY PROGRAM: AUGUST 1976 VERSION

Day	Content Area	Time Allocated for Each Content Area in Hours		Percent of Total Program Time Allocated to Each Content Area	
1	TOW Weapon System: Assembly Operation Loading and Unloading Procedure	.8		2.6	
	TOW Training Equipment: Operation Use	.8		2.6	
	TOW Crew Drill	.8		2.6	
	Gunnery Technique	.8		2.6	
	Table I Instructional Firing	2.5		8.0	
2	TOW Weapon System: Maintenance Battery Charging	1.7		5.5	
	Tank Identification	.8		2.6	
3	TOW Range Card Preparation	.8		2.6	
2-3	Tables II Through VI Instructional Firing	12.5		40.3	
	Training Total		21.5		69.4
4	Written and Hands-On Performance Test	3.5		11.3	
	Qualification Firing Test	4.0		12.9	
5	Graduation and TOW Live-Firing	2.0		6.4	
	Qualification Total		9.5		30.6

Table B-2

TRAINING METHODS AND NUMBER OF HOURS EACH METHOD WAS USED BY CONTENT AREA:
AUGUST 1976 USAIS TOW GUNNERY PROGRAM

Training Content Area	Lecture	Lecture and Demonstration	Conference	Practical Exercise	All Methods
TOW Weapon System: Assembly, Operation, Loading and Unloading Procedures	.1	.4		.3	.8
TOW Training Equipment: Operation and Use	.2	.6			.8
TOW Crew Drill		.5		.3	.8
Gunnery Technique	.2	.2		.4	.8
TOW Weapon System: Maintenance and Battery Charging	1	.6		1.0	1.7
Tank Identification	.1		.4	.3	.8
TOW Range Card Preparation	.2	.2		.4	.8
Table I Instructional Firing	.2			2.3	2.5
Tables II Through VI Instructional Firing	.2			12.3	12.5
All Content Areas	1.3	2.5	.4	17.3	21.5

Table B-3

INSTRUCTIONAL MEDIA BY TRAINING CONTENT AREA USED TO IMPLEMENT
THE AUGUST 1976 USAIS TOW GUNNERY PROGRAM

Training Content Area	Actual Equipment	Training Devices	Training Aid
TOW Weapon System: Assemble, Operation Loading and Unloading Procedures	Optical Sight Traversing Unit Tripod Launch Tube Missile Guidance Set	Missile Simulation Round	Chart Showing the Missile Guidance Set Control Panel
TOW Training Equipment: Operation and Use	Optical Sight Traversing Unit Tripod Launch Tube Missile Guidance Set	Missile Simulation Round Instructor Console Target Board/IR Transmitter Power Supply Modulator M80 Blast Simulator	Chart Showing the Instructor Console Control Panel Chart Showing the Power Supply Modulator Control Panel
TOW Crew Drill	Optical Sight Traversing Unit Launch Tube Missile Guidance Set M151 TOW Firing Vehicle M151 Missile Carrier APC TOW	Missile Simulation Round	
Gunnery Technique	Optical Sight Traversing Unit Tripod Launch Tube Missile Guidance Set	Missile Simulation Round	
TOW Weapon System: Maintenance and Battery Charging	Optical Sight Traversing Unit Tripod Launch Tube Missile Guidance Set Battery Charger	Missile Simulation Round	
Tank Identification	Binoculars	Tank Scale Models	Tank Identification Charts
TOW Range Card Preparation			Chart showing a Completed TOW Range Card Chalk Board with Chalk
Instructional Firing	Optical Sight Traversing Unit Tripod Launch Tube Missile Guidance Set	Missile Simulation Round Instructor Console Target Board/IR Transmitter Power Supply Modulator M80 Blast Simulator	

Table B-4

NUMBER AND TYPES OF SIMULATED FIRINGS CONDUCTED DURING INSTRUCTIONAL FIRINGS:
AUGUST 1976 USAIS TOW GUNNERY PROGRAM

Tracking Table	Target Stationary	Target Moving 5 Milliradians Per Second	Target Moving 15 Milliradians Per Second	Target Moving 25 Milliradians Per Second
I	6	6	6	-
II	-	6	6	6
IIIA	-	-	6	6
IIIB	-	10[a]	-	-
IV	-	12	-	-
V	-	6[b]	6[b]	6[b]
VI	-	10[b,c]	-	-
TOTAL	6	50	24	18

a Targets Moved Intermittently

b Blast Simulator Used

c Targets Tracked At Night

APPENDIX C

SUMMARY OF THE USAIS TOW GUNNERY TRAINING PROGRAM
15 APRIL 1977 VERSION

Table C-1

USAIS TOW GUNNERY PROGRAM: 15 APRIL 1977 VERSION

Day	Content Area	Time Allocated for Each Content Area in Hours		Percent of Total Program Time Allocated to Each Content Area	
1	TOW Weapon System: Assembly Operation Loading and Unloading Procedures	.8		2.8	
	TOW Training Equipment: Operation Use	.8		2.8	
	TOW Weapon System: Maintenance Battery Charging	.5		1.8	
	Gunnery Technique	.3		1.1	
	TOW Training Equipment: Practical Exercise in Operation and Use	.5		1.8	
	TOW Crew Drill	2.8		9.8	
	Table I Instructional Firing	1.2		4.2	
2-3	Tables II Through VIB Instructional Firing	12.5		44.0	
	Training Total		19.4		68.3
3	Hands-On Performance Test	3.0		10.6	
4	Qualification Firing Test	4.0		14.1	
5	Graduation and TOW Live-Firing	2.0		7.0	
	Qualification Total		9.0		31.7

Table C-2

TRAINING METHODS AND NUMBER OF HOURS EACH METHOD WAS USED BY CONTENT AREA:
15 APRIL 1977 USAIS TOW GUNNERY PROGRAM

Training Content Area	Lecture	Lecture and Demonstration	Practical Exercise	All Methods
TOW Weapon System: Assembly, Operation, Loading and Unloading Procedures	.2	.6		.8
TOW Training Equipment: Operation and Use	.1	.7		.8
TOW Weapon System: Maintenance and Battery Charging	.5			.5
Gunnery Technique	.3			.3
TOW Training Equipment: Practical Exercise in Operation and Use			.5	.5
TOW Crew Drill	.8		2.0	2.8
Table I Instructional Firing			1.2	1.2
Tables II Through VIB Instructional Firing			12.5	12.5
All Combat Areas	1.9	1.3	16.2	19.4

Table C-3

INSTRUCTIONAL MEDIA BY TRAINING CONTENT AREA USED TO IMPLEMENT
15 APRIL 1977 USAIS TOW GUNNERY PROGRAM

Training Content Area	Actual Equipment	Training Devices	Training Aid
TOW Weapon System: Assembly, Operation Loading and Unloading Procedures	Optical Sight Traversing Unit Tripod Launch Tube Missile Guidance Set	Missile Simulation Round	Chart Showing the Missile Set Control Panel
TOW Training Equipment: Operation and Use	Optical Sight Traversing Unit Tripod Launch Tube Missile Guidance Set	Missile Simulation Round Instructor Console Target Board/IR Transmitter Power Supply Modulator M80 Blast Simulator	Chart Showing the Instructor Console Control Panel Chart Showing the Power Supply Modulator Control Panel
TOW Weapon System: Maintenance and Battery Charging	Optical Sight Traversing Unit Tripod Launch Tube Missile Guidance Set Battery Charger	Missile Simulation Round	
Gunnery Technique	Optical Sight Traversing Unit Tripod Launch Tube Missile Guidance Set	Missile Simulation Round	
TOW Training Equipment: Practical Exercise in Operation and Use	Optical Sight Traversing Unit Tripod Launch Tube Missile Guidance Set	Missile Simulation Round Instructor Console Target Board/IR Transmitter Power Supply Modulator	
TOW Crew Drill	Optical Sight Traversing Unit Launch Tube Missile Guidance Set M151 TOW Firing Vehicle M151 Missile Carrier APC TOW	Missile Simulation Round	
Instructional Firing	Optical Sight Traversing Unit Tripod Launch Tube Missile Guidance Set	Missile Simulation Round Instructor Console Target Board/IR Transmitter Power Supply Modulator M80 Blast Simulator	

Table C-4

NUMBER AND TYPES OF SIMULATED FIRINGS CONDUCTED DURING INSTRUCTIONAL FIRING:
15 APRIL 1977 USAIS TOW GUNNERY PROGRAM

Tracking Table	Target Stationary	Target Moving 5 Milliradians Per Second	Target Moving 15 Milliradians Per Second	Target Moving 25 Milliradians Per Second
I	6	6	6	-
II	-	14	-	4
III	-	12	-	-
IV	-	16	8	-
V	-	10[a]	4[a]	4[a]
VIA	-	4[b]	4[b]	2[b]
VIB	-	6[a,c]	4[a,c]	-
TOTAL	6	68	26	10

[a] Blast Simulator Used

[b] Targets Moved Intermittently

[c] Targets Tracked at Night